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Developing Renewable Sources of Energy in Uzbekistan Renewable Energy Short Overview: Programs and Prospects

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Abstract. The model of the power complex will consist of several elements: a wind generator, photovoltaic panels, a diesel power plant and batteries, which will be created using block diagrams. For the analysis of the model, arbitrary initial data were introduced: meteorological parameters; number and capacity of storage batteries; solar module area; load schedule; wind turbine power. The theoretical place of testing the model was taken in Tashkent. The test results are graphs taken from oscilloscopes. After examining these graphs, we can conclude that the model is built correctly. The practical significance of the development of this model is not only the acceleration of the process of creating a real model of a mobile energy complex, but also the emergence of an opportunity for developers to choose the most optimal parameters of power supplies.
Keywords: Monitoring, solar radiation, mobile power complex, MatLab, renewable energy sources, decentralized power supply.

INTRODUCTION

The constant increase in energy consumption, the increase in the cost of electricity, the limited reserves of fossil fuels and the negative impact on the environment of power plants operating on fossil fuels - all this leads to the question of the need to switch to renewable energy sources. The solution of this issue is especially relevant for Uzbekistan, the energy system of which has a high degree of centralization. Almost 85% of the total volume of electricity is generated by large power plants, after which the electricity is fed into the general extensive power grid. This level of centralization of the energy system is typical for densely populated districts and some regions of Tashkent, while sparsely populated areas of Tashkent and a number of regions of the Far East (together forming a significant part of the territory of Uzbekistan) are characterized by a low level of connection to centralized energy systems. At the same time, it is not possible to lay high-voltage transmission lines to supply power to remote and sparsely populated villages, cities and industries from an economic and technical point of view. One of the possible solutions to this problem is the use of diesel or gasoline generators, which have a number of advantages and allow you to achieve the goals set for uninterrupted power supply to remote consumers. However, when considering the issue of providing electricity to consumers who have the first (or first special) category for the reliability of power supply, one cannot be limited to only one energy source. Failure of a diesel generator can result in significant financial damage, danger to human life and a threat to the country's security. Touching upon the environmental side of the issue of power supply to remote consumers, we note that the use of diesel generators creates conditions for environmental degradation (exhaust gases, loud noise, the risk of fuel and oil spills), therefore, when solving this problem, it is necessary to reduce the use of diesel generators to a minimum [1-5].

In general, the region of decentralized energy supply of the Far East includes 987 thousand people and 360 settlements. The total installed capacity of diesel power plants is 670 MW. The real crisis in the power supply of the Far Eastern Federal District has led to the question of the need to use renewable energy sources [6-10]. But in order to have a sufficient idea of the efficiency of RES in this region, let us consider the summary data on the potential of the Far East region in the field of renewable energy (table .1.).

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Assessment of the potential of wind-solar energy in the Far East Uzbekistan.

TABLE 1. The potential of renewable energy sources in Uzbekistan (million toe).

№	RES types	Gross	Technical	Mastered
1.	Hydropowe, total	9,2	2,32	0,72
2.	Includinglargerivers	8,0	1,81	0,56
3.	Small rivers, reservoirs and canals	1,2	0,51	0,16
4.	Solarenergy	50973	176,8	
5.	Windenergy	2,2	0,4	
6.	Biomass		0,5	
7.	Geothermalwaters	0,2	0	0
8.	Petrothermalresources *	6700000	0	0
9.	Total	50993,8**	182,32	0,72

**Heat of dry rocks. **Excluding petro thermal resources, for which there is no technology for use.*

In most of the isolated settlements of the Tashkent region, the level of solar activity varies from 750 to 1.1 thousand kWh per m^2 per year. For comparison, in Germany (the world leader in the use of solar power plants), the level of solar irradiation throughout the year fluctuates in the region of 0.9–1.2 thousand kWh per m^2 per year [11-15]. Comparison of indicators demonstrates the favorable location of the Far Eastern Federal District in terms of total insolation. The CIS insolation map is shown in Figure 1.

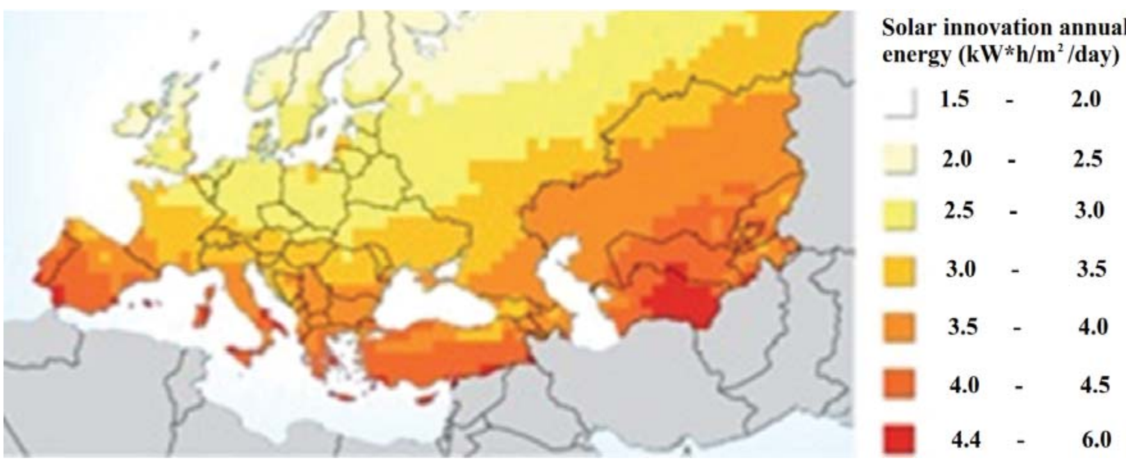


FIGURE 1. Insolation map of the CIS.

Analyzing this region from the point of view of wind energy, we can see that in the coastal regions of the Far East the average annual wind speed reaches 6-7 m / s. For comparison, in Denmark (the world leader in the use of wind turbines) this figure reaches a little more than 5 m/s, which also indicates the sufficient wind energy potential of the region [16, 17]. The map of the wind energy potential of the CIS is shown in Figure 2.

We conclude that the resources of the sun and wind in the Tashkent regions are sufficient to supply power to decentralized consumers. Taking into account the great complexity of laying power lines in this region and the desire to minimize the use of diesel generators, the question arises of providing electrical energy to remote consumers using renewable energy sources [18].

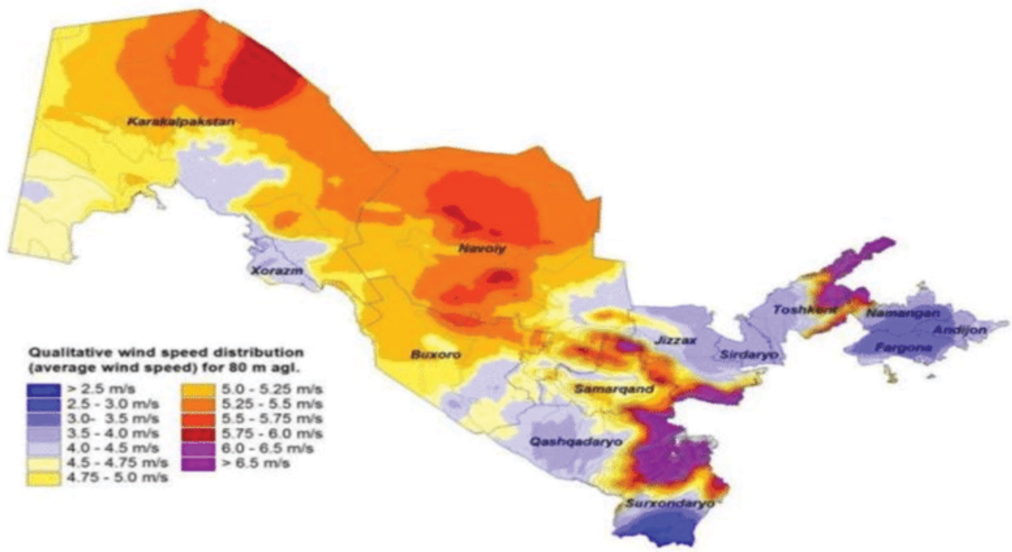


FIGURE 2. Atlas of wind speed distribution across the territory of Uzbekistan [19].

Scientists of the Tashkent State Technical University took up this issue, starting the development of a mobile energy complex based on renewable energy sources. All elements of the mobile power plant are located in a transport container on a trailer towed by a car, or in a van body of a military mobile complex. The creators of this complex, in addition to ensuring the compactness of the main components of the power plant (wind power plant, solar panels and diesel power plant), as a backup power source, are faced with the task of modeling the entire power complex in the MatLab package.

MAIN BODY

Theoretical Analysis

Modeling is one of the most important stages in the design of a mobile power complex for decentralized power supply, in the process of which it is necessary to consider many factors and parameters before deciding on the device of an independent power supply system, including the components of generation and storage of energy. The most important moments for design are the type of renewable energy sources used, the amount of energy they can generate, climatic, topographic and geographical parameters of the area, the type of loads and the specificity of the need for electricity [20]. The block diagram of the proposed mobile energy complex is shown in Figure 3.

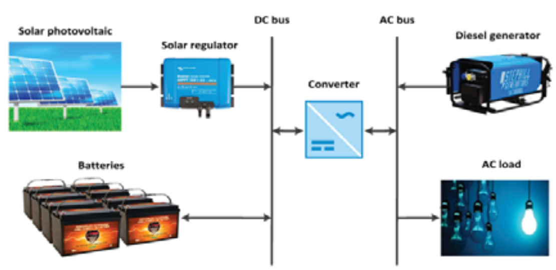


FIGURE 3. Scheme of a hybrid energy complex based on RES and DES

The power complex consists of the following components: a solar photovoltaic plant (SFEU), a wind power plant (WPP), a diesel power plant (DPP) and energy storage units (batteries), which are connected to a DC bus to coordinate the operating modes of the power complex components with each other and are connected to the useful and ballast

load. The complex should provide the consumer with a continuous supply of electricity, while he should use the potential of renewable energy sources to the maximum, and if they are not enough, start supplying the consumer with energy from a diesel generator. In the event of a short-term power shortage, it is necessary to use an installed energy storage device (battery pack), switchable (one is switched on for charging, and the other for discharge) [21-30].
A situation is possible when the consumer's load is small, and the energy storage device is fully charged, the diesel generator is off, and renewable sources generate more energy than necessary, then it is necessary to apply a ballast load to consume excess electricity. In any other situation, the ballast load must be disconnected.

RESULTS AND DISCUSSION

The platform for modeling will be the MatLab/Simulink package - this is a graphical simulation environment that allows building dynamic models using block diagrams. We begin the development of the model with the statement of the problem: it is required to build a model of a hybrid scalable power complex based on renewable energy sources as close as possible to reality [31-33]. At the moment, it is not possible to build a model that fully corresponds to reality due to the lack of specific data on the components of the complex. The model of the hybrid energy complex is shown in Figure 4.

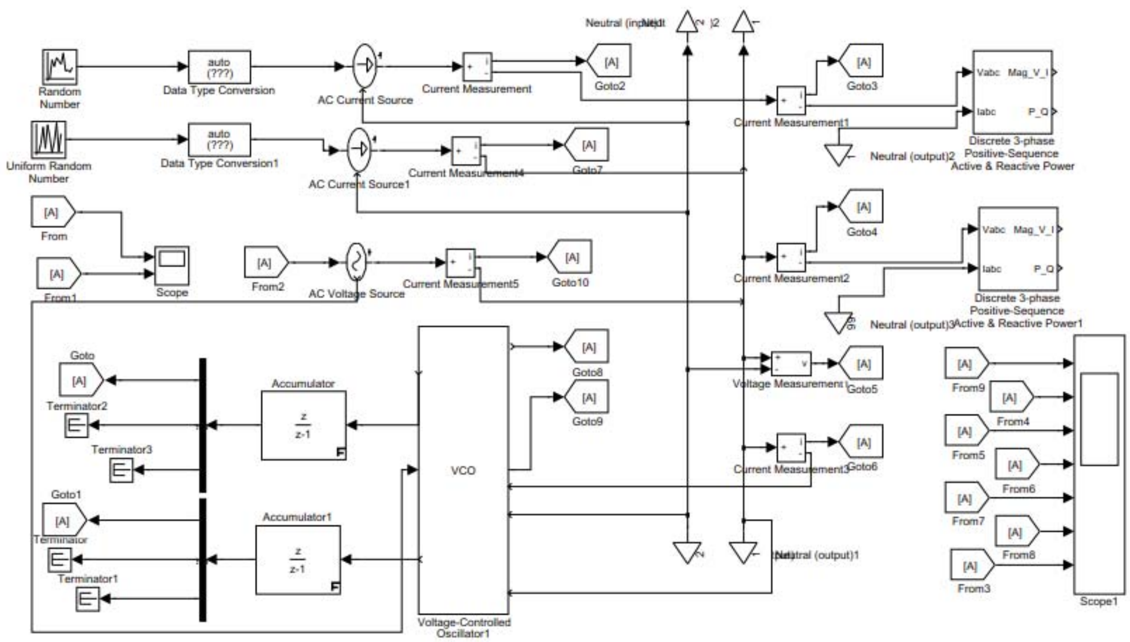


FIGURE 4. Model of a scalable hybrid power complex in MatLab.

Brief description: the DC bus is represented as negative (node 10) and positive (node 20) potentials located in the middle of the model. On the left side of the model there are renewable energy sources (solar photovoltaic plant, wind power plant) and a diesel generator connected to the DC bus, on the right side of the model there are payload and ballast loads [36].

EQUATIONS AND MATHEMATICS

In the role of units of renewable energy sources we will use controlled current sources, and as a generator - a voltage source [34]. The management of these elements can be described by the following dependencies:

$$I_{S.P} = f(G_i, S, U_{DC}), \quad (1)$$

where $IS.P$– current drawn from solar panels; G_i– current flux of solar radiation onto the surface of the solar module; S – total area of solar panels; UDC – DC bus voltage.

$$I_{W.T} = f(V_w, S, U_{DC}), \quad (2)$$

where $I_{W.T}$– wind current; V_W– current wind speed; $P_{r.p}$ – rated power of the wind turbine; UDC – DC bus voltage.

$$U_{D.G} = f(U_{bat}), \quad (3)$$

whereU_{DG}- diesel generator voltage; U_{bat}- battery voltage in charge mode.
The transformation of solar radiation into amperage is carried out according to the formulas:

$$P_S = \eta S G_i, \quad (4)$$

whereP_S-power generated by solar modules; η – Solar module efficiency; S – total area of solar modules.

$$I_S = \frac{P_S}{U_{DC}}, \quad (5)$$

whereI_S- solar module current; U_{DC}DC bus voltage.
Dependence $I_{SUN} = f(G_h, S, U_{DC})r^2$ of this model is shown in Figure 5.

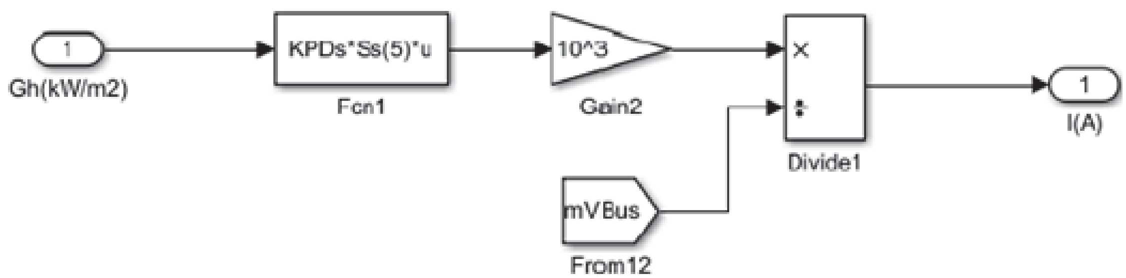


FIGURE 5. Simulation of dependence$I_{SUN} = f(G_h, S, U_{DC})$

The wind turbine is described as follows: one of the ways to set the wind turbine is to set the dependence of the generated power of the wind turbine on the wind speed: $P_v = f(V_w)$ Based on the parameters of a particular unit, you can describe this dependence according to the formulas:

$$P_V = 0 \qquad V_W < V_{min}$$
$$P_V = aV_W^3 - bP_{номV} V_{min} \leq V_W < V_{ном}$$
$$P_V = P_{номV} V_W \geq V_{ном}$$
$$P_V = 0 V_W \geq V_{max}$$
$$a = \frac{P_{номV}}{V_{ном}^3 - V_{min}^3}, \ b = \frac{V_{min}^3}{V_{ном}^3 - V_{min}^3},$$

Where $P_{r.p.V}$– rated power of the wind turbine taking into account efficiency; V_W – current wind speed; V_{min}, $V_{ном}$, V_{max}– minimum and maximum wind speeds that determine the operating mode of the wind turbine, a, b are correction factors [35].
Dependence $I_{W.P} = f(V_W, P_{ном}, U_{DC})$ of this model is shown in Figure 6. Modeling of a diesel generator is carried out by creating a voltage source of infinite power, implying that a real unit will be designed to meet the needs of electric consumers with a margin, as well as to cover the costs of own needs [36]. The payload is shown as a model in Figure 7.
A load graph as a Simulink element is created in an Excel document, where a real or arbitrary load graph (kW) is built. Having created a load graph in the Simulink environment, you need to convert it into a current graph that is consumed during the day, for which you need to introduce a variable resistor into the circuit. Unfortunately, this element is not in the library, so let's build the payload subsystem ourselves (Figure 8).

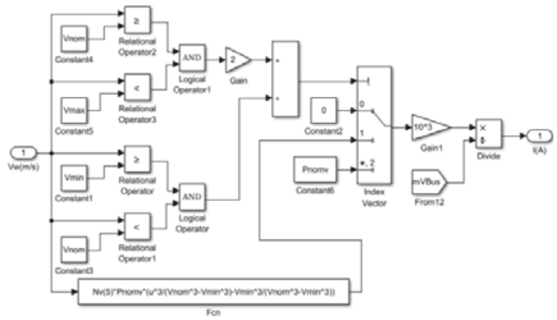


FIGURE 6. Simulation of dependence *IW .P =f (VW , P*r.p. *,UDC*

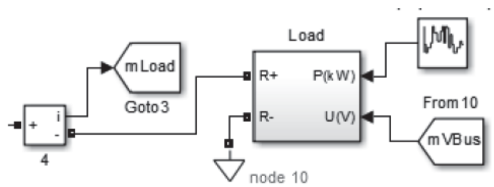


FIGURE 7. Simulation of the payload

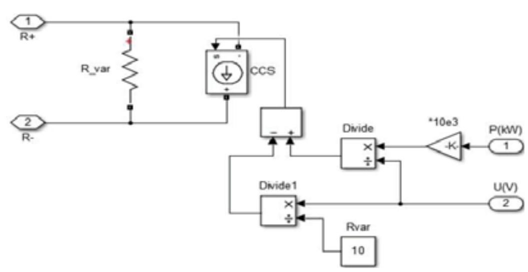


FIGURE 8. Payload subsystem

The above diagram is a Simulink subsystem that has two power terminals and two control terminals. The main element is a resistor R_{var} with an arbitrary specified resistance of 8 Ohm [37]. The maximum possible current flowing through such a resistor (at U = const) is U/8. The ballast load is shown as a model in Figure 9.

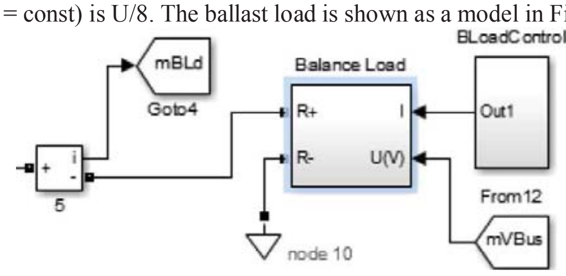


FIGURE 9. Simulation of ballast load

The ballast load is designed to compensate for the excess of generated energy by renewable sources. In fact, this is a variable resistor, which is why the structure of this element will be similar to the payload circuit, but with a different kind of control [38]. The ballast load subsystem is shown in Figure 10.

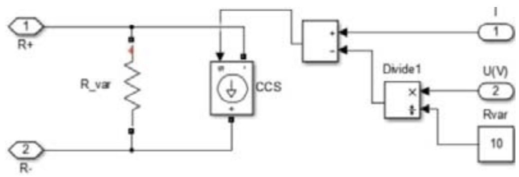


FIGURE 10. Subsystem of ballast load

An indispensable component of the circuit is a block with batteries and their control system. It is necessary to maintain a constant voltage on the DC bus and prevent an extreme discharge of the batteries, since this will entail a deep voltage drop, for which they should be switched among themselves in time [39]. The battery pack model is shown in Figure 11.

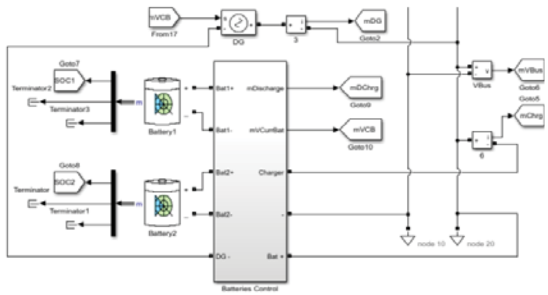


FIGURE 11. Battery pack model

CONCLUSIONS

To test this model, let's enter arbitrary initial data: meteorological parameters; number and capacity of storage batteries; solar module area; load schedule; wind turbine power.
A random load graph for June for Tashkent city is shown in Figure 12 [40,41].

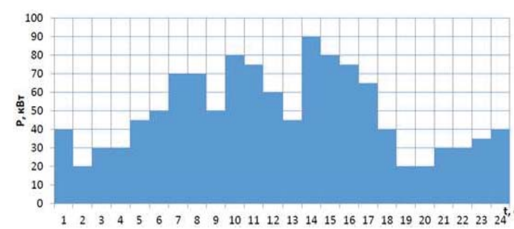


FIGURE 12. Arbitrary load schedule for June for Tashkent [42].

The results of the tests will be the results of the graphs taken from the Scope and Scope 1 oscilloscopes (Figure 13, 14, 15).[43,44].

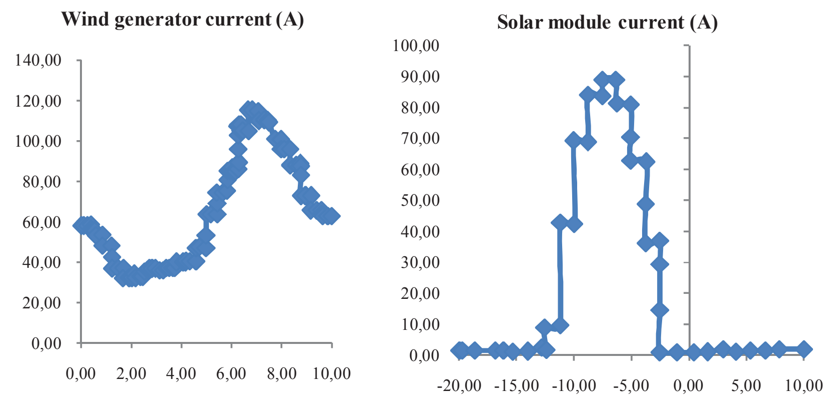


FIGURE 13. Graphs of the dependence of the current of the wind generator and solar modules on the time of day

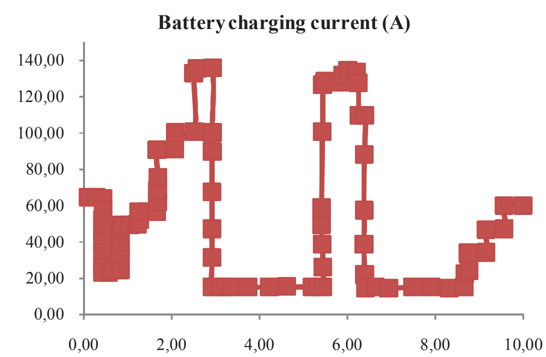
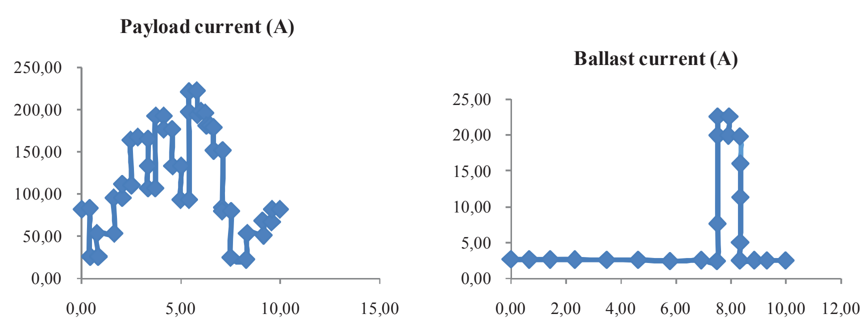


FIGURE 14. Graph of the dependence of the battery charge current on the time of day



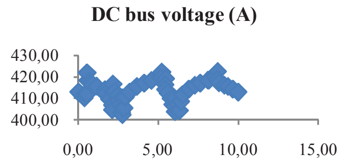


FIGURE 15. Graphs of the dependence of the current of the payload and ballast loads on the time of day and voltage on the SHPT on the time of day

Having analyzed the graphs taken from the oscilloscopes, we can conclude that the model is functioning correctly. At moments of excess generated energy, a ballast load is included in the circuit. The DC bus voltage ranges from 410-423 V, which also indicates that the system is operating correctly. In spite of the fact that during the modeling process the assumption was made: the modeling was carried out only at direct current, and the power balance was not violated, this convention made it possible to simplify the model, since there was no longer a need to model massive converters. Nevertheless, it is necessary to take into account a large number of factors that, in general, can affect the realistic model. This model will help speed up the design of the power complex and increase the efficiency of selecting the optimal parameters for the components involved in generating electricity. Thanks to the designed model, it became possible to organize more detailed monitoring of the functioning of each of the model components.

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